

Amendments to the Claims

The following listing of claims will replace all prior versions and/or listings of claims in the application:

Listing of Claims:

1-2308. (cancelled)

2309. (previously presented): A method of treating a coal formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from one or more of the heat sources to a part of the formation;

controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range; and

controlling the heat to yield at least about 15 % by weight of a total organic carbon content of the part of the formation into condensable hydrocarbons.

2310. (previously presented): The method of claim 2309, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the part of the formation.

2311. (previously presented): The method of claim 2309, further comprising maintaining a temperature within the part of the formation within a pyrolysis temperature range of about 270 °C to about 400 °C.

2312. (previously presented): The method of claim 2309, wherein one or more of the heat sources comprise electrical heaters.

2313. (currently amended): The method of claim 2309, wherein ~~one or more~~ at least one of the heat sources ~~comprise surface burners~~ comprises a surface burner.

2314. (currently amended): The method of claim 2309, wherein ~~one or more~~ at least one of the heat sources ~~comprise flameless distributed combustors~~ comprises a flameless distributed combustor.

2315. (currently amended): The method of claim 2309, wherein ~~one or more~~ at least one of the heat sources ~~comprise natural distributed combustors~~ comprises a natural distributed combustor.

2316. (previously presented): The method of claim 2309, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2317. (cancelled)

2318. (currently amended): The method of claim 2309, wherein providing heat from one or more of the heat sources to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from one or more of the heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 1 °C/day ~~10 °C/day~~.

2319. (original): The method of claim 2309, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2320. (previously presented): The method of claim 2309, wherein allowing the heat to transfer

from one or more of the heat sources to the part of the formation increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

2321. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2322. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2323. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2324. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2325. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2326. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2327. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2328. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2329. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2330. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2331. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2332. (previously presented): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2333. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2334. (original): The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2335. (previously presented): The method of claim 2309, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2336. (original): The method of claim 2309, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

2337. (previously presented): The method of claim 2309, further comprising producing a mixture from the formation, wherein a partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2338. (original): The method of claim 2309, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2339. (original): The method of claim 2309, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2340. (previously presented): The method of claim 2309, further comprising:

providing hydrogen (H_2) to the heated part of the formation to hydrogenate hydrocarbons within the part; and

heating a portion of the part with heat from hydrogenation.

2341. (previously presented): The method of claim 2309, further comprising:

producing hydrogen (H_2) and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2342. (previously presented): The method of claim 2309, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2343. (previously presented): The method of claim 2309, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part of the formation is substantially uniform.

2344. (original): The method of claim 2309, wherein the heating is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by Fischer Assay.

2345. (original): The method of claim 2309, further comprising producing a mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

2346. (original): The method of claim 2309, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

2347. (original): The method of claim 2309, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2348. (previously presented): A method of treating a coal formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from one or more of the heat sources to a part of the formation;

controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range; and

controlling the heat to yield greater than about 60 % by weight of total condensable hydrocarbons, as measured by Fischer Assay.

2349. (previously presented): The method of claim 2348, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the part of the formation.

2350. (previously presented): The method of claim 2348, further comprising maintaining a temperature within the part of the formation within a pyrolysis temperature range of about 270 °C to about 400 °C.

2351. (previously presented): The method of claim 2348, wherein one or more of the heat sources comprise electrical heaters.

2352. (currently amended): The method of claim 2348, wherein ~~one or more~~ at least one of the heat sources ~~comprise surface burners~~ comprises a surface burner.

2353. (previously presented): The method of claim 2348, wherein ~~one or more~~ at least one of the heat sources ~~comprise flameless distributed combustors~~ comprises a flameless distributed combustor.

2354. (currently amended): The method of claim 2348, wherein ~~one or more~~ at least one of the heat sources ~~comprise natural distributed combustors~~ comprises a natural distributed combustor.

2355. (previously presented): The method of claim 2348, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2356. (cancelled)

2357. (currently amended): The method of claim 2348, wherein providing heat from one or more of the heat sources to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from one or more of the heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 1 °C/day ~~10 °C/day~~.

2358. (original): The method of claim 2348, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2359. (previously presented): The method of claim 2348, wherein allowing the heat to transfer from one or more of the heat sources to the part of the formation increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

2360. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2361. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2362. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2363. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2364. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2365. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2366. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5

% by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2367. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2368. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2369. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2370. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2371. (previously presented): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2372. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2373. (original): The method of claim 2348, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2374. (previously presented): The method of claim 2348, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2375. (original): The method of claim 2348, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

2376. (previously presented): The method of claim 2348, further comprising producing a mixture from the formation, wherein a partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2377. (original): The method of claim 2348, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2378. (previously presented): The method of claim 2348, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen (H₂) from the mixture into the formation.

2379. (previously presented): The method of claim 2348, further comprising:
providing hydrogen (H₂) to the heated part to hydrogenate hydrocarbons within the part;

and

heating a portion of the part with heat from hydrogenation.

2380. (previously presented): The method of claim 2348, further comprising:
producing hydrogen (H₂) and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion
of the produced hydrogen.

2381. (previously presented): The method of claim 2348, wherein allowing the heat to transfer
increases a permeability of a majority of the part of the formation to greater than about 100
millidarcy.

2382. (previously presented): The method of claim 2348, wherein allowing the heat to transfer
comprises increasing a permeability of a majority of the part of the formation such that the
permeability of the majority of the part of the formation is substantially uniform.

2383. (original): The method of claim 2348, further comprising producing a mixture in a
production well, and wherein at least about 7 heat sources are disposed in the formation for each
production well.

2384. (original): The method of claim 2348, further comprising providing heat from three or
more heat sources to at least a portion of the formation, wherein three or more of the heat sources
are located in the formation in a unit of heat sources, and wherein the unit of heat sources
comprises a triangular pattern.

2385. (original): The method of claim 2348, further comprising providing heat from three or
more heat sources to at least a portion of the formation, wherein three or more of the heat sources
are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a
triangular pattern, and wherein a plurality of the units are repeated over an area of the formation
to form a repetitive pattern of units.

2386-5149. (cancelled)

5150. (previously presented): The method of claim 2345, wherein at least about 20 heat sources are disposed in the formation for each production well.

5151. (previously presented): The method of claim 2309, wherein the part of the formation comprises a selected section.

5152. (previously presented): The method of claim 2309, wherein a pyrolysis zone is established in the part of the formation.

5153. (previously presented): The method of claim 2309, wherein a pyrolysis zone is established in the part of the formation proximate to and/or surrounding at least one of the heat sources.

5154. (previously presented): The method of claim 2309, wherein at least one of the heat sources is disposed in an open wellbore.

5155. (previously presented): The method of claim 2383, wherein at least about 20 heat sources are disposed in the formation for each production well.

5156. (previously presented): The method of claim 2348, wherein the part of the formation comprises a selected section.

5157. (previously presented): The method of claim 2348, wherein a pyrolysis zone is established in the part of the formation.

5158. (previously presented): The method of claim 2348, wherein a pyrolysis zone is established in the part of the formation proximate to and/or surrounding at least one of the heat sources.

5159. (previously presented): The method of claim 2348, wherein at least one of the heat sources is disposed in an open wellbore.

5160. (previously presented): A method of treating a coal formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation,
wherein the heated portion of the formation is proximate one or more of the heat sources;
allowing the heat to transfer from the portion of the formation to a part of the formation;
inhibiting introduction of oxygen or air into the part when temperature in the part is in a pyrolysis temperature range; and
controlling the heat to yield at least about 15 % by weight of a total organic carbon content of the part of the formation into condensable hydrocarbons.

5161. (previously presented): The method of claim 5160, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the part of the formation.

5162. (previously presented): The method of claim 5160, wherein the part of the formation comprises a selected section.

5163. (previously presented): The method of claim 5160, wherein a pyrolysis zone is established in the part of the formation.

5164. (previously presented): The method of claim 5160, wherein at least one of the heat sources comprises a natural distributed combustor.

5165. (previously presented): The method of claim 5160, wherein at least one of the heat sources is disposed in an open wellbore.

5166. (previously presented): The method of claim 5160, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part of the formation is substantially uniform.

5167. (previously presented): The method of claim 5160, wherein providing heat from one or more of the heat sources to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from one or more of the heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5168. (previously presented): The method of claim 5160, further comprising maintaining a temperature within the part of the formation within a pyrolysis temperature range, wherein the pyrolysis temperature range is from about 250 °C to about 370 °C.

5169. (previously presented): The method of claim 5160, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5170. (previously presented): The method of claim 5160, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5171. (previously presented): The method of claim 5160, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5172. (previously presented): The method of claim 5160, further comprising providing hydrogen (H_2) to the part to hydrogenate hydrocarbons within the part.

5173. (previously presented): The method of claim 5160, further comprising producing fluid from the formation, wherein the fluid comprises hydrogen (H_2); and introducing a portion of the H_2 into the part.